($2\frac{1}{2}$ Hours) **[Total Marks : 60]**

N.B. (1) Figures to the right indicate full marks.
(2) All questions are compulsory.
(3) Use of non-programmable calculator is allowed.
(4) Symbols have their usual meaning unless stated otherwise.

Constants: $k = 1.38 \times 10^{-23} m^2 kg s^{-2} K^{-1}$
$q = e = 1.602 \times 10^{-19} C$,
$\varepsilon = 8.854 \times 10^{-12} m^{-3} kg^{-1} s^4 A^2$

Q.1 a) Attempt any **one**

(i) Using continuity equation, derive the expression for minority carrier density under steady state carrier injection from one side of a semi-infinite sample. **8**

(ii) Describe the Haynes-Shockley Experiment to demonstrate the drift and diffusion of the minority charge carriers. **8**

b) Attempt any **one**

(i) Write a short note on the Hall Effect and state its two applications. **4**

(ii) A sample of germanium is made of p-type material by adding acceptor atoms at a rate of one atom per 4×10^8 germanium atoms. $n_i = 2.5 \times 10^{19} /m^3$ at 300 K. All the acceptor atoms are ionized at 300 K. The density of germanium atoms is $4.4 \times 10^{28} /m^3$. Compare the density of electrons with intrinsic charge carriers. **4**

Q.2 a) Attempt any **one**

i) Obtain the total depletion layer width as a function of built-in potential for an abrupt p-n junction. **8**

ii) Describe the junction breakdown mechanisms: **8**
(1) Tunneling Effect,
(2) Avalanche Multiplication, with the help of suitable diagrams.

b) Attempt any **one**

(i) With the help of neat diagram, explain the working of a p-n junction solar cell. **4**

(ii) Discuss the importance of generation-recombination centers in the study of practical diode characteristics. **4**

Q.3 a) Attempt any **one**

i) Draw the energy band diagram of a metal – n type semiconductor contact in thermal equilibrium. Hence find the value of the built in potential V_{Gi}. Explain, how does the energy band diagram gets modified under forward and reverse bias condition? **8**

ii) Discuss the switching action of a pnp transistor. Explain how the switching action of the transistor can be improved? **8**

b) Attempt any **one**

i) Write short note on quantum well structures. **4**

ii) With the help of a neat diagram, discuss the structure of Heterojunction bipolar transistor. **4**

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Q.4 a) Attempt any **one**

i) What is an ideal MOS diode? Discuss the accumulation, depletion and inversion conditions in ideal MOS diode with the help of energy band diagram. **8**

ii) With the help of a neat diagram explain the principle of operation of MESFET. Also discuss its current voltage characteristics. **8**

b) Attempt any **one**

i) Explain the MODFET fundamentals. **4**

ii) Explain the MOSFET operation using its I-V characteristics. **4**

Q.5 Attempt any **four**

(a) A silicon sample at T = 300 K contains an acceptor impurity concentration of $N_A = 10^{16}\ /cm^3$. Determine the concentration of donor impurity atoms that must be added so that the silicon is n-type and the Fermi energy is 0.20 eV below the conduction band edge. **3**
Given :$N_c = 2.86$ x10^{19} /cm^3 $KT = 0.0259\ eV\ at\ T = 300\ K$

(b) In an n-type semiconductor at T = 300 K, the electron concentration varies linearly from 1 x 10^{18} to 7 x 10^{17} /cm^3 over a distance of 0.1 cm. Calculate the diffusion current density if the electron diffusion coefficient is D = 22.5 cm^2/s. **3**

(c) For an ideal abrupt silicon p$^+$ -n junction with $N_D = 8 \times 10^{15} cm^{-3}$, calculate the stored minority carriers per unit area in the neutral region when a forward bias of 1V is applied. The diffusion length of the holes is 5μm. **3**

(d) Write a short note on depletion capacitance. **3**

(e) For a W-Si Schottky diode, the saturation current density is $J_s = 4.2 \times 10^{-5} A/cm^2$s. Find the barrier height at 300K. **3**
Given: A* = 110 A/K^{2}cm^2.

(f) Show that common base current gain α_0 for a pnp transistor is the product of emitter efficiency γ and the base transport factor α_T. **3**

(g) You are given an n- channel GaAs MESFET at T= 300K with gold contact. The n- channel doping is 2 x 10^{15} cm^{-3} and the channel thickness is 0.6μm. Calculate the pinch-off voltage. The dielectric constant of GaAs is 12.4. **3**

(h) Write note on fabrication of integrated circuit resistor. **3**

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